Regional Analyses of Restoration Planning

PART 1 – PACIFIC NORTHWEST

ESTUARIES OF THE PACIFIC NORTHWEST

The Pacific Northwest region is defined here as the coasts of Alaska, Washington (including Puget Sound) and Oregon.

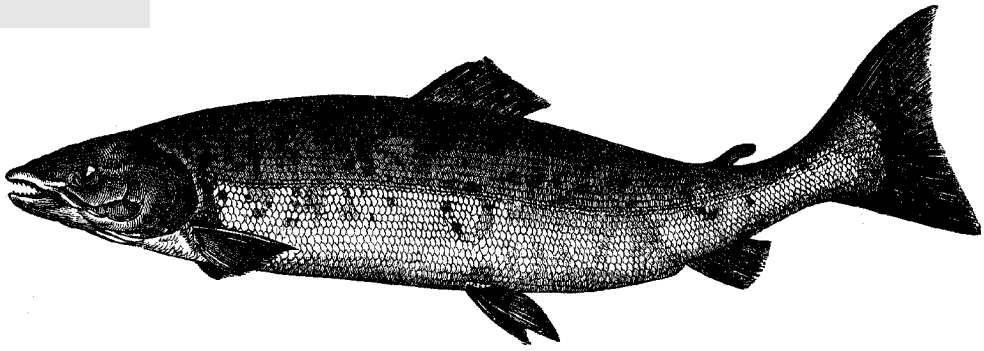
This region:

- Has more than 40,000 miles of shoreline that contain thousands of identified salmon streams, hundreds of estuaries, the largest known single stand of eelgrass in the world (37,000 to 39,000 acres) and the largest wetland complex (700,000 acres) on the Pacific Coast (Ward et al., 1997; Frost and Logan, 2001; McRoy and Goering, 1974).
- Contains more than 3,000 square kilometers (1,200 square miles) of tidal wetlands.
- Receives freshwater flow from approximately 25 percent of the land area of the United States.

These estuaries support more than 90 percent of the nation's harvest of wild and hatchery-raised salmon, as well as rapidly growing coastal communities such as the recreational and seaport towns of coastal Oregon and Washington, the greater Seattle area in Puget Sound and the coastal communities of southeast Alaska, including Anchorage.

SUMMARY

The Pacific Northwest region has experienced extensive habitat loss in Puget Sound and other coastal estuaries of the Northwest. Invasion and spread of Spartina alterniflora is a growing concern in this region. In Alaska, the *Exxon Valdez* oil spill in 1989 acted as a catalyst for intensive ecosystem research. As a result, an abundance of information relating to marine resources has been compiled. Significant damage to the Oregon and Washington coasts and the Columbia River Estuary has occurred over the past years. For example, more than 50 percent of the tidal marshland in the Columbia River Estuary has been destroyed. Although regional estuarine restoration planning is still developing in the Pacific Northwest, examples of regional planning include the Salmon Recovery Plan in Washington and the Lower Columbia River Estuary Plan for Oregon and Washington. Plans also exist for individual estuaries and sub-basins. A national estuarine restoration strategy and federal funding would contribute significantly to the development and implementation of comprehensive, regional estuarine restoration strategies.



Introduction to the Pacific Northwest

Description

The following analysis provides a brief overview of the state of estuarine restoration planning in the Pacific Northwest. It is intended to support *A National Strategy* by highlighting the losses of, and threats to, key Pacific Northwest habitats; the current efforts to set and achieve restoration goals; and some of the research needs that have been identified for effective restoration.

For purposes of this analysis, the Pacific Northwest has been divided into three subregions: Alaska, Puget Sound, and the Oregon and Washington coasts and Columbia River Estuary.

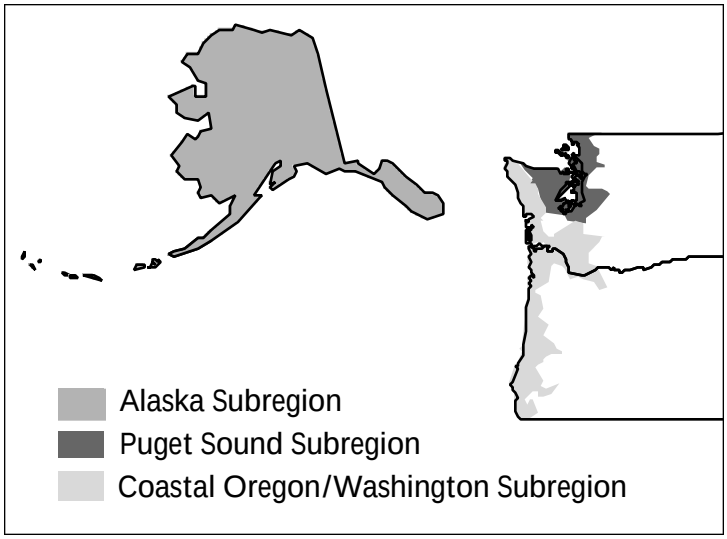


Figure 1. Pacific Northwest Region and Subregions

Key Habitats and Species

A tremendous diversity of ecosystems characterizes the Pacific Northwest region. These include tidal marshes and wetlands, intertidal and mud flats, kelp beds, the largest bed of seagrass along the Pacific coast of North America and the largest known single stand of eelgrass in the world—located in the Izembek Lagoon (Ward et al., 1997). These habitats are essential for several estuarine-dependent species and serve as spawning and rearing habitat for a number of fish. In the Alaskan subregion, habitats include intertidal flats, salt marshes, streams and riparian habitats, rocky substrates, mud flats, eelgrass beds and kelp beds which provide rockfish habitat (USDOC, 1998). Intact nearshore ecosystems (including adjacent upland, intertidal and shallow subtidal habitats), riparian habitat/sloughs, gravel beds and streams (which act as tidal freshwater spawning and rearing areas), tidal marshes, mud and sand flats, freshwater wetlands, eelgrass beds, and gravel beaches are key habitats in the Puget Sound subregion (Dean et al., 2000; HRPC, 1998; USFWS and NOAA, 1996; USFWS, 2000;). In the Coastal Oregon and Washington subregion, habitats that are primary candidates for restoration and conservation efforts include tidal marshes and wetlands, rivers and streams, mudflats, and eelgrass beds (Donnelley, 1994; Hoffmann, 2001; LCEMP, 1982; McColgin, 1979).

Estuarine marshes constitute a complex ecosystem that is vital to a number of different species. These species include macroinvertebrates (clams, oysters, sea urchin and sea stars), shellfish (Dungeness crab), fish (Pacific salmon, capeline, flounder and sole, gaddids, rockfish, smelt and herring), mammals (seals, sea lions and whales) and birds. The estuarine habitats in the northwest are important for feeding, nesting, rearing and migratory staging for a number of birds throughout the year. In 1996, Kachemak Bay was dedicated as an international site of the Western Hemisphere Shorebird Reserve Network. An international site designation indicates that the site hosts more than 100,000 shore birds or a 10 percent flyaway population (USDOC, 1998).

The *Exxon Valdez* Trustee Council evaluated the recovery status of some organisms, particularly those found in the Alaska subregion. These labels designate certain species as "recovered," "recovering," "not recovered" or "recovery unknown." Some species that are listed as recovering include clams, mussels, Pacific salmon and Pacific herring. The killer whale and the harbor seal are two species that have been identified as not recovered (*Exxon Valdez* Oil Spill Trustee Council, 1999*b*).

The highest density of the large geoduck shellfish in the Pacific Northwest can be found in Puget Sound (WDH et al., 1999). This species uses the sandy mud of the lower intertidal and subtidal habitats and has been identified as a species in need of protection. Key fish species in the Puget Sound area, specifically mentioned for protection by the Washington Department of Ecology, include sandlance *(Ammodytes hexapterus)*, surf smelt *(Hypomesus pretiosus)*, Pacific herring *(Clupea harengus pallasi)*, gaddids (cod fishes), and rockfish (multiple species) (WDE, 1993).

Intertidal mudflats and beaches provide resting and feeding areas for gulls, herons, shore birds and waterfowl. Underwater kelp forests shelter snails, crabs, shrimp, starfish, sea anemones, sea cucumbers, brittle stars, sea squirts and many other marine organisms. Damage to eelgrass beds affects whole populations of finfish (including threatened salmon, herring, gunnels and pipefish) waterfowl, shellfish, Dungeness crabs, and nudibranchs. Shoreline stability also is jeopardized by damage to eelgrass beds.

Riparian corridors are another habitat that can have beneficial impacts on the estuarine environment. Because of their linear form, they are able to process large fluxes of energy and materials (e.g., nutrients, large woody debris, gravels and fines, oxygenated water) from upstream systems and are laterally connected to upslope (upland) and downslope (aquatic) ecosystems as well as upstream and downstream features. These riparian zones become refuge for a variety of animals as they provide a diversity of habitat and an abundance of water that allow for often distant migration. Primary productivity is generally higher in a riparian corridor than in the adjacent upland community due to the diversity and abundance of resources in riparian corridors. These ecosystems act as a nutrient sink for lateral runoff from uplands and as a nutrient transformer for in-stream flows (Mitsch and Gosselink, 1993). Riparian corridors contribute to the stability of global levels of available nitrogen, atmospheric sulfur, carbon dioxide and methane through nutrient cycling in living plant material. They also moderate the effects of floods; improve water quality; limit erosion by stabilizing streambanks; and provide shelter and spawning habitat for a variety of wildlife species including anadromous fish, waterfowl, reptiles, amphibians, insects and a variety of megafauna.

The major causes of stream and estuarine habitat degradation have been historical forestry practices, impediments to fish passage (e.g., dams and other obstructions), increased shoreline development and spill events. Many historical forestry practices did not take into consideration riparian management concerns in relation to fish habitat and water quality. Presently, forestry practices manage for the adequate preservation of fish habitat by maintaining a short- and long-term source of large woody debris, stream bank stability, channel morphology, water temperature, stream flows, water quality, adequate nutrient cycling, food sources, clean spawning gravels and sunlight-to-shade ratio. Depending on state regulations, current restrictions may apply to forested areas within 25 to 300 feet from streambanks and on steep slopes adjacent to riparian corridors. Urban shoreline development and port activities have placed an increased stress upon marine resources as in- and over-water structures, shoreline armament, accidental groundings (e.g., barges, log-booms, oil tankers, personal marine vessels), wood-waste accumulation from nearshore log transfer facilities, and the legal and illegal filling of wetlands and navigable waters have increased.

The Columbia River Basin provides habitat for six species of anadromous salmonids (chinook, coho, chum, sockeye, pink and steelhead). All of these species except the pink salmon are listed as federally threatened under the Endangered Species Act. Saltwater transition zones in rivers are extremely important for juvenile salmonids during the critical smoltification process, when they undergo behavioral, physiological and morphological changes to prepare for oceanic life. During this transition period and during residence, juvenile salmonids, particularly chum and under-yearling chinook, migrate to the more saline portions of estuaries and gain weight (USFWS, 2000). For more detailed information on habitat needs and threats for salmon species, refer to the discussion under California's Anadromous Fish Species section of the California and Pacific Islands regional analysis.

Habitat Status and Trends

The Pacific Northwest region has experienced extensive habitat loss in many of its coastal estuaries. Between 50 and 90 percent of riparian habitat in Washington has been lost or extensively modified (WDNR, 2000). Threats such as diking, draining, filling, development, pollution, and the invasion and spread of Spartina alterniflora all contribute to estuarine degradation in this region.

In the Alaska subregion, a major cause of estuarine habitat degradation has been the Exxon Valdez oil spill in 1989. The spill contaminated about 1,500 miles of Alaska's coastline. Since then, significant efforts have been made to protect and restore the Alaskan shoreline. Thousands of acres of wetlands and estuaries in Alaska also have been impacted by fill, port development and sewage disposal for example.

Puget Sound has experienced rapid estuarine habitat loss, especially in urban areas (e.g., Commencement and Elliot Bays). The Sound functions as vital nursing and foraging grounds for wildlife and fisheries resources, such as the endangered chinook salmon. Restoration efforts in the Sound include transplanting eelgrass and removing invasive species. Because Canada geese forage on eelgrass, it is often necessary to surround transplanted eelgrass with Geese Excluder Devices (GEDs) to protect young plants. Organizations such as People for Puget Sound are developing models to engage in large-scale estuarine restoration projects in the Sound.

In the Coastal Oregon and Washington subregion, there has been extensive loss of coastal and estuarine habitat. Large expanses of tidal marshland and wetlands have been lost due to diking, draining, filling and development. Regional approaches to estuarine restoration are underway, such as the Lower Columbia River Estuary Plan. This plan is a multi-agency effort to restore habitat along the Lower Columbia River. Restoration projects will benefit endangered salmon species and other fish and wildlife resources that inhabit estuaries of the Lower Columbia River.

Regional Planning Efforts

Restoration efforts in the Pacific Northwest region occur under the auspices of federal, tribal, state and local authorities, as well as through the efforts of nongovernmental entities such as business and industry groups, academic institutions, nonprofit organizations and community groups. These efforts have different levels of coordination depending on whether they are located within National Estuary Programs or have other coordinating mechanisms. A specific discussion of planning efforts in each subregion can be found in the sections to follow.

Pacific Northwest Subregions

For purposes of this analysis, the Pacific Northwest has been divided into three subregions: Alaska, Puget Sound, and the Oregon and Washington coasts and Columbia River Estuary.

The following sections summarize the habitat issues and highlight certain restoration planning efforts for each of the Pacific Northwest subregions. Additional information and detailed information about these documents are available through the National Strategy Restoration Plan Database at http://restoration.nos.noaa.gov.

ALASKA SUBREGION

Description

Various types of coastal and estuarine restoration projects occur in Alaskan waters. These include restoration of wetland, riparian (including shoreline and riverbank stabilization) and instream (including salmon spawning) habitats; non-native predator removal projects; water quality monitoring in relation to forest harvesting activities; and seagrass restoration.

Since the *Exxon Valdez* spill in 1989, much has been learned about the marine environment of Alaska. The disaster provided a catalyst for intense ecosystem research and led to an abundance of information about resources in the waters that was previously unknown. Not only did this research assist in restoring critical areas of Prince William Sound, but the event promoted the importance of contingency measures leading to the creation of safer oil transportation systems. The *Exxon Valdez* Oil Spill Trustee Council continues to work to restore and protect affected areas.

In close proximity to the spill site in Prince William Sound lies Kachemak Bay National Estuarine Research Reserve, which promotes education, research and interpretation of information about estuaries. Institutions such as this may serve as representative entities of restoration in Alaska, with their emphasis on an ecosystem approach toward restoration, the development of strong monitoring programs, and the inclusion of the public throughout the restoration process.

Under the Alaska National Interest Lands Conservation Act of 1980 and The Wilderness Act of 1964, protection and restoration is continually proposed to benefit watersheds and their associated marine resources. Two examples of recent proposals include the Alaska Rainforest Protection Proposal for the Chugach National Forest (www.inforain.org/maparchive/chugach_proposal.htm) and the Alaska Rainforest Protection Proposal for the Tongass National Forest (www.inforain.org/maparchive/tongass_forest_proposal.htm).

Habitat Issues

Status and Trends

Significant damage to Alaska's coasts and estuaries has been caused by various threats in this subregion including the *Exxon Valdez* oil spill. Since then, efforts have been made to repair the damage done and to prevent further degradation. More than 1,400 miles of shoreline, including haul-out areas for harbor seals, the mouths of more than 300 salmon streams, and nesting and foraging habitat for black oystercatchers have been protected. In February 1999, the Eyak Corporation completed a package with the Trustee Council to protect 75,452 acres in eastern Prince William Sound. In addition, the Large Parcel program of the Trustee Council protects a total of 635,770 acres of land in Alaska.

Threats

Within the Alaska subregion, losses and degradation of key habitats may be attributed to the following threats: used oil, household hazardous waste and scrap metals; mass wasting from forestry practices; urban and port development; roads and roadway runoff; wastewater and sewage disposal; oil and gas development, including associated pipelines and underwater utility lines; impacts associated with tourism development; gravel mining; and natural events.

Restoration Plans

Several planning efforts with a regional focus exist in the Alaska subregion. Brief summaries of these efforts are outlined below. A full listing of plans and additional information can be found on the National Strategy Restoration Plan Database (http://restoration.nos.noaa.gov).

Kachemak Bay National Estuarine Research Reserve

The Kachemak Bay National Estuarine Research Reserve was established in 1999 and currently encompasses 365,000 acres

of protected estuarine lands and waters. The reserve management plan was approved by the National Oceanic and Atmospheric Administration in 1999. Important habitats that may be useful as reference sites include upland forests, glaciers and glacial streams, tidal flats, brackish marshes and rocky intertidal areas.

Exxon Valdez *Oil Spill Restoration Plan*

This plan provides long-term guidance for restoring the resources and services injured by the 1989 oil spill. It contains policies for making restoration decisions and describes how restoration activities will be implemented.

Alaska's Refuges, Critical Habitat Areas and Sanctuaries

The Alaska State Legislature has classified certain areas as being essential to the protection of fish and wildlife habitat. These areas are managed by the Alaska Department of Fish and Game and designated as either a refuge, critical habitat area, or sanctuary. While they suffer from a variety of historical and current disturbances, all of these designated areas maintain high floral and faunal diversity. The level at which conservation and/or restoration practices are applied differ from region to region with an emphasis placed on shoreline, nearshore and estuarine habitats. It has been largely those areas which have been affected by either oil spill damage or by the threat of commercial development and/or commerce that have received a majority of these efforts to date. For more information, see www.state.ak.us/adfg/habitat/geninfo/refuges/refuges.htm.

Plan Elements

Goals

Several goals were identified in the plans for the Alaska subregion. It was emphasized that restoration should contribute to a healthy, productive and biologically diverse ecosystem within the spill area that supports the services necessary for the people who live in the area. Another goal is to take an ecosystem approach toward restoration to better understand what factors control the populations of injured resources. Restoration goals also focused on full ecological recovery; a recovered ecosystem provides the same functions and services that would have been provided had the spill not occurred. In this system, populations of flora and fauna are again present at former or pre-spill abundances, are healthy and productive, and represent a full complement of age classes at the level that would have been present had the spill not occurred. Another goal is to provide opportunities for long-term research, education and interpretation of trends in estuarine conditions.

Methods

Several methods have been used or recommended for achieving the subregion's restoration goals. Among these are replanting seagrasses, macroalgae, creating fish passes to restore fish populations, redirecting hunting and fishing harvest, managing human disturbance around sensitive bird colonies, and reducing marine pollution.

Elements of Success

Common principles of successful estuarine restoration are apparent in the planning efforts for the Alaska subregion. These include statements of clear, measurable and achievable endpoints; protection of habitat at the watershed level; designation of criteria for setting priorities for projects (e.g., cost effectiveness, likelihood of success, possible harmful side effects, etc.); and multi-disciplinary, interagency or collaborative partnerships.

Monitoring also has been identified as an important element of successful restoration. The Gulf Ecosystem Monitoring Program for the northern Gulf of Alaska, to begin in October 2002, covers Prince William Sound, lower Cook Inlet, Kodiak Island and the Alaska Peninsula. Its mission is "to sustain a healthy and biologically diverse marine ecosystem in the northern Gulf of Alaska and the human use of those resources through greater understanding of how productivity is influenced by human activities and natural changes." Successful monitoring programs focus on more than resource-specific investigations; they include a long-term approach to understanding the physical and biological interactions that affect an injured resource or service. The System-Wide Monitoring Program (SWMP) collects information on abiotic parameters, biodiversity and land use patterns to create a system of national reference sites for estuarine trends.

Public participation and education also can play an important role in successful restoration. Documentaries (e.g., the Alaska SeaLife Center anniversary exhibit), inclusion of an annual report in school curricula, radio and newspaper reports, and newsletters (e.g., The Restoration Update) can increase the effectiveness and ultimate success of a restoration effort. Establishment of a public advisory group is an important aspect as well. The *Exxon Valdez* Trustee Council has its own public advisory group that advises the trustees on all matters related to planning, evaluation and allocation of funds, as well as the planning, evaluation and conduct of injury assessments and restoration activities. Other key elements include community involvement programs, public participation in projects at all levels, and timely release of and reasonable access to information about restoration projects.

Adaptive management can be an important element in a successful restoration project. Restoration priorities need to embody a long-term, ecosystem view that is continually updated as new information is acquired so that the most current ecological, social and economic information is used in formulating decisions.

Information Needs

Most of the information needs in the Alaska subregion relate to understanding the impact of human activity on estuarine habitats and the function of these habitats for fish and essential fish habitat. Also needed is a comprehensive inventory of Alaska's estuarine habitats.

Puget Sound Subregion

Description

The geographic scope of the Puget Sound subregion covers subestuaries and nearshore habitats of the entire Puget Sound basin, including but not limited to the water bodies of the Straits of Georgia and Juan de Fuca, Admiralty Inlet, Hood Canal and adjacent waters.

Puget Sound is one of the most unusual estuaries in the United States, in that deep marine waters invade a heavily urbanized lowland region to form a vast inland sea. Many economic benefits are incurred from shipping, fishing, and residential and commercial development. Furthermore, the cultural and aesthetic values we associate with the Sound and its natural resources are celebrated by both tribal and nontribal communities.

Estuaries like Puget Sound embody the interface between freshwater and saltwater. These areas are usually sheltered from the forces of the ocean and harbor large quantities of plant and animal life. The Sound is used as nursing and foraging grounds by many animal species. Natural regimes of tidal influence and freshwater input are vital to the ecology of the estuary, and changes in the tidal flow or freshwater quality and quantity as a result of human disturbance can alter and eradicate many plant and animal communities. Drying of wetland areas can have a dramatic effect, as can the introduction of exotic species. Changing conditions push out native species and upset ecosystem relationships. It is therefore important to maintain local native relationships (water, soil, plants, and animals) to prevent the disappearance of some species or the disruption of the healthy functioning of others.

Habitat Issues

Status and Trends

Puget Sound has experienced an immense amount of wetland loss:

- More than 70 percent tidal wetlands were lost in the past century, and 33 percent of marine shorelines have been modified (PSWQAT, 2000; Belcher, 2000).
- In Skagit Valley, 37 of the original 40 square miles of wetlands are estimated to have been lost, resulting in a 93 percent total loss (Belcher, 2000).
- In urban areas such as Seattle and Tacoma, the loss of salt marsh is close to 100 percent (WDE, 2000).
- At least 35 percent of Washington's threatened and endangered species require healthy wetlands for survival (PSWQAT, 2000).

Puget Sound's shorelines have been severely altered by development:

- Human activities have modified about 800 miles, or one-third, of Puget Sound's shoreline; 25 percent of these modifications have occurred in intertidal areas (Belcher, 2000).
- Up to 52 percent of central Puget Sound's shoreline and about 35 percent of the shorelines of Whidbey Island, Hood Canal and south Puget Sound have been modified (Belcher, 2000).
- Since the arrival of settlers in the early 1800s, at least 50 percent and as much as 90 percent of riparian habitat in Washington has been lost or extensively modified (Belcher, 2000).

In the Puget Sound area, specific degraded habitats need to be highlighted because of their importance to estuarine functions. These include eelgrass beds, shellfish beds and benthic habitats:

- 33 percent of eelgrass beds have been lost as a result of dredging, filling and diking (White, 1997).
- Eelgrass in Elliott and Commencement Bays is all but absent (some does exist in subtidal areas).
- The Snohomish River Delta has lost 15 percent of its original eelgrass beds (Belcher, 2000).
- Eelgrass beds in Bellingham Bay have declined by about 50 percent over the past 100 years (Belcher, 2000).
- Since 1980, roughly 25 percent of the area classified for commercial shellfish harvesting has been downgraded and taken out of production because of high water concentrations of pathogenic bacteria (WDH et al., 1999).
- A focused study of urban embayments revealed that 35 percent (5,250 acres) of 15,000 acres are contaminated above state sediment quality standards (PSWQAT, 2000).

- More than 3,000 acres of Puget Sound's sediments are so contaminated that federal law requires that they be cleaned up (Belcher, 2000).
- Between 1992 and 1996, Washington discharged 1.5 million pounds of potentially cancer-causing pollutants directly into the water—more than any other state (Belcher, 2000).

The spread of invasive species presents a great threat to native organisms, and their control remains a challenge in restoration efforts. More than 52 invasive species were discovered in Puget Sound in 1998 (Belcher, 2000).

Threats

Within the Puget Sound subregion, losses and degradation of key habitats can be attributed to the following threats: dredging and disposing of sediments; nonpoint source pollution, toxic chemicals (PCBs, PAHs, etc.) metals; shellfish contaminants (marine biotoxins, bacteria and viruses, chemicals); marinas and recreational boating; population growth; agricultural practices; aquaculture development; erosion; urban development and shoreline armoring; forestry management practices; altered drainage patterns from filling, dredging, ditching, and diking; invasive species (*Spartina, zostera japonica* [eelgrass], *Sargassum muticum* [kelp]); culverts, dams, and tide gates; septic system failure; nutrient enrichment; port development, shipping, and transportation; protection of newly established plants from geese and other herbivores; and discarded debris in intertidal and subtidal habitat.

Restoration Plans

An overall management plan exists for the Puget Sound area that contains specific tasks for federal, state, tribal and local governments: the Puget Sound Water Quality Action Team's Marine and Freshwater Habitat Protection Program Long-range Plan (www.wa.gov/puget_sound/Programs/Habitat.htm). Additional subregional plans have been developed and some are included in the discussion below. A full listing of plans and detailed information can be found on the National Strategy Restoration Plan Database (http://restoration.nos.noaa.gov).

2000 Puget Sound Water Quality Management Plan

This plan is the state of Washington's long-term strategy for protecting and restoring Puget Sound. This plan provides the framework for managing and protecting the sound and coordinating the roles and responsibilities of federal, state, tribal and local governments.

1999-2001 Puget Sound Water Quality Work Plan

This plan lays out a two-year strategy to continue work to protect the Sound's health in the face of new and continuing problems. The plan provides the framework for an ongoing comprehensive and coordinated approach to protect and restore the Sound.

Plan Elements

Goals

The Puget Sound Water Quality Action Team, the National Estuary Program for Puget Sound, coordinates agencies involved in restoration and protection of Puget Sound. The Action Team developed and maintains a comprehensive management plan with the goal of preserving, restoring and enhancing the ecological processes that create and maintain marine and freshwater habitats and to achieve a net gain in ecological function and area of those habitats within the Puget Sound basin. Due to the large geographic area and the number of entities involved in restoration, this broad goal is designed to set the standard for restoration into the future but does not replace the need to develop individual restoration goals that are more geographically distinct or site specific.

Other goals that have been identified in restoration plans for the Puget Sound area are to:

- Improve water quality.
- Achieve no net loss of wetlands function and acreage.
- Use best shoreline development practices (erosion control).
- Follow holistic ecosystem management.
- Conduct restoration on an estuary-wide basis.
- Ensure adaptability to new developments in science and restoration technology.
- Provide for management by a panel representing federal, state, tribal and local governments to maximize joint opportunities.
- Limit the amount of funding spent on planning and studies.
- Integrate and coordinate sediment remediation, habitat development and source control.
- Set priorities for projects and implementation of cost-effective methods.
- Have a regional jurisdictional entity (e.g., port district, county, state) eventually absorb responsibility for monitoring and stewardship.
- In the long term, achieve a measurable net gain of wetlands function and acreage and a net gain of aquatic and riparian habitat important to protection of water quality.

Methods

Several methods have been used or recommended to achieve the subregion's restoration goals.

- Breach dikes, open dikes to restore natural flood cycles, redivert water and control drainage.

- ❖ Develop and implement marine protected areas (MPAs) or marine sanctuaries.
- ❖ Evaluate potential sites and criteria for regional management plans and provide evaluation to determine success.
- ❖ Provide management at the local level.
- ❖ Revegetate, retaining detritus and salmon carcasses for nutrient cycling.
- ❖ Install and maintain streamside fencing, bioengineering approaches to bank stabilization; apply fill removal, excavation, and for stream daylighting, create a new surface water channel and mouth to provide intertidal habitat.
- ❖ Maintain and/or provide large woody debris in riparian corridors that have been altered due to inappropriate land use activities.
- ❖ Modify substrate; amend upland soils, import soil for establishment of emergent marsh area.
- ❖ Control erosion (e.g., use logs, large rocks or other materials to protect the emergent zone from wave action; install wattling or shrub plantings for bank stabilization).
- ❖ Remove and control *Spartina* (use "Integrated Weed Management approach" as suggested by Washington's 1993 Noxious Emergent Management Plan EIS; use herbicide, mow and spray regime).
- ❖ Plant eelgrass in areas that have the appropriate physical characteristics (salinity, depth, substrate, water clarity, etc.).

Elements of Success

A variety of elements have proven successful in restoration efforts.

- ❖ Define roles for stakeholders and public participation.
- ❖ Creating a panel for each project of cooperating agencies to establish goals, review, set priorities for and recommend projects, collect and disseminate information, and address a variety of information specific to assigned areas.
- ❖ Developing and implement a long-term site management plan after restoration.
- ❖ Building on smaller restoration projects to increase rates of success.
- ❖ Designing and build projects in the context of a larger landscape approach.
- ❖ Using adaptive management to monitor sites and make appropriate changes over time; collect, evaluate, update and distribute information about ongoing programs and projects to improve water quality and salmon habitat.

Site selection and planning:

- Evaluate site elevation, tidal flow, freshwater input, and substrate type versus the habitat requirements of restored vegetation community.
- Establish selection criteria (current and historic locations, conditions, functional trajectories and ownership), use "space-for-time substitution," set priorities for projects (e.g., cost effectiveness, the relative potential of the cleanup or restoration to benefit fish and wildlife).
- Consider several reference sites as a model for restoration.
- Conduct thorough site planning that includes hydrologic analysis, grading plans, soil conditioning or amendment, planting plans and specifications, and timetables and schedules.
- Collect pre-project information in the context of the current and historic landscape. Through review of a historic and current habitat inventory, reconstruction of the current delta may be attempted.
- Conduct functional assessments before and after the project. Standardize data through hydrogeomorphological (HGM) assessments.
- Create a selection process that filters proposals for accurate assessment of a project's importance and feasibility.

Monitoring:

- Development of programs to monitor project effectiveness.
- Development of a quantitative approach for measuring progress.
- Designation of a lead entity to oversee site stewardship, monitoring and implementation of contingency measures.
- Involvement of volunteers in monitoring of restoration projects. Volunteer stewardship groups and conservation organizations should be tapped to carry out monitoring tasks, to control program costs and foster community support for stewardship of completed restoration projects. Reviews by a lead agency can ensure data quality. Programs need continual review so that as specific criteria have been met, the associated monitoring tasks cease.
- Adoption of standard protocols to which performance criteria can be compared. Possible monitoring could include below-ground and above-ground biomass, inventory of fish and amphibian resources, bird use by habitat type (point counts, breeding bird surveys), invertebrate surveys, vegetation surveys, and channel formation. Monitoring should be related to goals via a conceptual model.

Education and public participation:

- Educate and publicly involve all stakeholders to establish a sense of ownership in the restoration measures and educate the public about how to prevent further degradation. Educational initiatives should be tailored to each specific audience.
- Determine the role of the public in the project.
- Develop and distribute materials for a comprehensive edu-

cational program and maintain it through partnerships with other agencies. In Puget Sound, the Public Involvement and Education Fund supports educational programs.
- Provide educational workshops for landowners on implementing best management practices that protect water quality, streams, wetlands and fish habitat. At least half of the workshops will target livestock owners.
- Educate the public on the need for a large-scale framework for project selection and development
- Bring all stakeholders into the process of project screening and approval early to avoid problems and delays later.
- Create a Public Participation Committee, to allow people to comment early and throughout the planning program via meetings and workshops. Conduct interviews with stakeholders to extract opinions and recommendations. The long-term viability of restoration projects relies in part on community understanding and acceptance of restored natural features in the urban landscape.

Funding:

- The U.S. Environmental Protection Agency has provided financial assistance to tribes and local communities in the Puget Sound basin to develop aquatic habitat protection plans.
- The non-regulatory Natural Lands Plan provides financial incentives to individual property owners to preserve critical areas and agricultural and forestry activities. It also provides for restoration and protection of degraded wetlands and stream corridors and recommends various funding strategies to augment the capacity to acquire high-priority lands.
- Local cost-share of capital improvements.
- The Corporate Wetland Restoration Partnership, founded in 1999 by Gillette in Massachusetts, combines corporate contributions with federal and state funds to restore degraded tidal and freshwater wetlands.
- Having separate funds for construction and scientific research aspects of restoration projects ensures that goals for both will be met.
- The state of Washington's Salmon Recovery Funding Board has significant state and federal funds (tens of millions of dollars) available annually for habitat restoration and acquisition, and has language in its guidelines specifically soliciting estuarine and marine nearshore projects.
- Ports and port associations are possible sources of matching funds.
- The North American Wetlands Conservation Act of 1989 provides matching grants to private or public organizations or to individuals who have developed partnerships to carry out wetlands conservation projects in the United States, Canada and Mexico.
- The Coastal Wetlands Planning, Protection and Restoration Act authorizes the director of the U.S. Fish and Wildlife Service to grant funds to coastal states (including states bordering the Great Lakes) to carry out coastal wetlands conservation projects.

Information Needs

The analysis of plans identified the following common areas where additional research is needed on restoration techniques and methods:

- Estimates of recovery time for estuaries to determine what is attainable and sustainable over time (information about threshold sizes equilibrium points).
- Better tools for project evaluation and success criteria.
- Data to create a baseline map of potential wetlands within the watershed. Wetlands need to be characterized and functional attributes assessed so that changes in conditions can be recognized.
- Baseline monitoring: information about onsite conditions before construction of the restoration project; data collected in the first year after the restoration project; information from reference sites; information from literature reviews of similar situations; and information from studies of existing, undisturbed estuaries.
- More information on the interaction between natural coastal processes and human land use as they relate to salmon production.
- Spatial and computer models to establish links between human activities and conditions in marine and freshwater environments (e.g., to investigate and eliminate sources of pollution upstream that could affect work downstream).
- Overlays of key habitats (and other types) with land use zoning designations to predict areas that are likely to be degraded through addition of impervious area.
- The influence of upper watershed activities on lower watershed work.
- A sample subset of sites of different ages where dikes have been breached by natural means (e.g., storms) and monitoring of how long natural restoration of these sites takes.
- Examination of projects in the context of the greater watershed or a landscape approach. A method is needed for scientific classification of estuaries by their watershed characteristics.

Issues identified in need of further research and testing include:

- Cost-effective methods to study the survival of biological populations in habitats or the changes in survival caused by lack of refuge or other limiting factors like available food sources.

- Climate change and the rise of sea level may require flexibility in the estimated tidal levels incorporated into restoration projects. More research is needed in this area so that planning efforts can accurately take these issues into account.
- The identification of sites through mitigation plans provides a potentially important resource. These plans often represent a substantial body of work, identifying a surplus of target sites beyond the scope of the proposed mitigation. Examples of potentially useful project lists driven by mitigation requirements include the Elliott Bay/Duwamish Restoration Panel, the Commencement Bay Natural Resource Damage Assessment Environmental Impact Statement and Restoration Plan, and the Snohomish Estuary Wetland Integration Plan and Salmon Overlay.
- An information clearinghouse that collects baseline information on Puget Sound sites, including aerial photographs, soil maps and project designs. This makes comparisons among sites difficult and thus complicates planning and construction of future restoration projects. It is essential to follow the changes in geomorphology and ecology of restoration sites so that recommendations for future projects can be based on pre-existing projects. Designation of a lead agency to compile these records would be helpful.

Oregon and Washington Coasts and Columbia River Estuary Subregion

Description

Oregon and Washington's coastal estuaries are areas of high biological productivity. They provide critical habitat for many species of cultural, commercial and recreational importance, including several species listed as endangered and threatened under the Endangered Species Act. Since colonization, many of the region's estuaries have been affected by altered hydrology, urbanization, water pollution and the introduction of exotic species. This has had a negative impact on salmon and other finfish and shellfish species, as well as on eelgrass beds, tidal marshes and general biodiversity.

Widespread agricultural and urban development of coastal lowlands in the Pacific Northwest began relatively late in the history of the United States. By the time the coastal areas of Washington and Oregon were settled, our society had developed clear goals for and efficient methods of converting tidal wetlands to other land uses via diking, dredging and filling activities. As a result, thousands of acres of biologically productive estuarine habitat have been lost to development. Although agricultural use of converted lands was dominant early in the last century and remains important in the region, increasing urbanization of coastal communities is resulting in more substantial and permanent alteration of coastal lands and surrounding estuarine waters.

Restoration of these critical estuarine habitats will be essential to recover and maintain the biological productivity of the Pacific Northwest's coastal waters. Restoration efforts are in progress along the Washington and Oregon coasts under the management of federal, state, tribal and local authorities and through the efforts of nongovernmental entities and community groups. Some management plans include sections on restoration that may not have been implemented yet; others already have been completed. There has been considerable effort to re-create habitat rather than simply mitigate damage.

Habitat Issues

Status and Trends

The following statistics reflect significant damage to the Oregon and Washington coasts and Columbia River Estuary.

- More than half the tidal marshland and 70 percent of the tidal wetlands have been destroyed in the Columbia River Estuary since 1870. Only 10 percent of the historic anadromous fish stock remains (Jerrick, 1999).
- South Slough National Research Reserve contains less than 10 percent of the original salt marsh (Donnelley, 1994).
- Tillamook Bay has lost 85 percent of marshlands to diking and draining. Historical tidal wetlands covered 5.52 square miles; 0.3 square mile is native wetland and 1.3 square miles have been restored (NEP and US EPA, 1999).
- Since the 1800s, urbanization converted 90 percent to 98 percent of Washington's coastal wetlands (WDNR, 2000).
- Only 35 percent of Washington's estuaries have good water quality (WDNR, 2000).
- Willapa Bay's infestation of Spartina, an exotic species, is projected to increase from 3,200 acres in 1997 to 30,000 acres in 2030 (WDNR, 2000).
- Yaquina Bay has lost 14 percent of its tidelands to filling (LCEMP, 1982).
- Juveniles of more than 70 species of fish use Oregon's estuaries to forage (Oberrecht, undated).

Threats

Primary threats in this region include modification and loss of habitat through diking, draining, damming*, tide gates, culverts, filling, structures (such as sea walls, jetties and docks), water diversions and altered flow, and dredging; sedimentation problems in the estuary often caused by anthropogenically altered hydrology; loss of biodiversity, especially through invasive or exotic species; degradation of water quality (e.g., elevat-

ed fecal coliform bacterial levels, non-point source pollution); agricultural and forestry practices (e.g., creation of pastureland, erosion, suspended sediments); and Canada geese, a resident species that feed on intertidal plant species, but in some cases can be detrimental to the health and growth of restored wetland plants.

*Dams are a major threat to the migration patterns of Pacific salmon. The physical presence of dams, and the creation of reservoirs, impedes juvenile and adult migrations to and from the ocean. The reservoirs behind the dams slow water velocities, alter river temperatures and increase predation potential. Reduced water velocity increases the time it takes juveniles to migrate downstream. Higher water temperatures may have adverse effects on juvenile and adult behavior, and predators find prey more easily in slower-moving water. Since 1991, the National Marine Fisheries Service (NMFS) has listed 12 "Evolutionarily Significant Units," of Columbia River Basin salmon and steelhead as threatened or endangered under the Endangered Species Act.

Restoration Plans

Although Oregon and Washington do not now have comprehensive estuarine restoration strategies, they have all the elements necessary to develop and implement such strategies. Both states have a statewide framework for land use and estuary or shoreline planning and management; a framework to identify and provide funding for watershed restoration projects; a system of grassroots organizations empowered to identify appropriate restoration sites and projects; and a prototype information system that can assist in the identification of estuarine restoration sites. A national estuarine restoration strategy and federal funding would contribute significantly to the use of these elements in the development and implementation of comprehensive regional estuarine restoration strategies.

Activities in Oregon's estuaries are governed largely by an element in Oregon's Statewide Comprehensive Land Use Program. Oregon law requires all local governments to adopt comprehensive land use plans in compliance with a series of "Statewide Planning Goals." There are 19 such goals; four apply exclusively to coastal resources, one specifically to estuaries. Thus, all of Oregon's major estuaries are governed by "estuary management plans," available on the internet (www.inforain.org/mapsatwork/oregonestuary/). In addition, the Lower Columbia Estuary Program (www.lcrep.org/home.htm) and the Tillamook Bay National Estuary Project (www.co.tillamook.or.us/gov/estuary/tbnep/nephome.html), participants in the U.S. EPA's National Estuary Program, were created to develop partnerships between government agencies that oversee estuarine resources and the people who depend on the estuaries for their livelihood.

Washington has two relevant statewide planning laws. The Growth Management Act requires jurisdictions to locate critical areas such as wetlands, steep slopes, aquifer recharge areas and important fish and wildlife habitat areas, develop ordinances to protect them and incorporate them into county-wide comprehensive land use plans. The Shoreline Management Act requires local jurisdictions to designate appropriate land uses along a 200-foot-wide shoreline zone and develop policies to protect the appropriate land uses for each designation, ranging from shoreline conservancy to shoreline industrial. Both of these planning frameworks receive guidance and programmatic oversight from state agencies and include a public participation and appeals process. The coastal zone of Washington is further managed by the state Department of Ecology through broad, comprehensive coastal management policies. The coastal zone contains three planning regions, the lower Columbia National Estuary Program, the Olympic National Marine Sanctuary and Puget Sound, each with comprehensive management plans.

A full listing of plans and more detailed information can be found on the National Strategy Restoration Plan Database (http://restoration.nos.noaa.gov).

Columbia River Estuary Regional Management Plan

This plan expresses decisions of the Columbia River Estuary Study Taskforce Council on estuarine management issues including restoration, land and water use, dredged material management and mitigation.

Lincoln County Estuary Management Plan

The Lincoln County Estuary Management Plan provides an overall, integrated management scheme for estuarine aquatic areas in Lincoln County and contains comprehensive provisions for guiding estuarine development and conservation activities.

Lower Columbia River Estuary Plan

The Lower Columbia River Estuary Plan was developed by a committed group of citizens participating in the Lower Columbia River Estuary Program. The plan focuses on a unique and critical part of the Columbia River system: the Lower Columbia River. It identifies how to best preserve and enhance this resource.

Padilla Bay National Estuarine Research Reserve

The Padilla Bay National Estuarine Research Reserve was established in Washington in 1980 and currently encompasses

10,700 acres of protected estuarine lands and waters. The reserve management plan was prepared in 1984 and is currently being revised. Important habitats that may be useful for investigation and as reference sites include tidal flats and sloughs, salt marshes and seagrass beds. Restoration priorities include removal of fish migration blockages and salmon recovery by means of restoration of riparian zones and estuarine sloughs. Restoration of salt marshes, mudflats and eelgrasses may include removal of invasive species, woody debris and toxic materials such as creosote logs. Current restoration projects include Spartina alterniflora control that preserves and restores native salt marshes and mudflats.

Salmon Recovery Plan

In May 1997, Washington Governor Gary Locke and thirteen agency heads signed a memorandum of agreement to establish a forum to serve as the "formal and ongoing institutional framework to promote interagency communication, coordination and policy direction on environmental and natural resource issues." This forum is known as the Joint Natural Resources Cabinet (JNRC). To bring together a wider forum to assist with the review and development of a three-part effort to recover salmon, the Government Council on Natural Resources (GCNR) was developed. In order to assist the JNRC and GCNR in accomplishing their mission, the Governor's Salmon Recovery Office was established by the Legislature through the Salmon Recovery Planning Act (Engrossed in Substitute House Bill 2496). The Salmon office's role is to coordinate and produce a statewide salmon strategy, assist in the development of regional salmon recovery plans, and submit the strategy and plans to the federal government. The office also provides the Biennial State of the Salmon report to the state legislature.

South Slough National Estuarine Research Reserve

The South Slough National Estuarine Research Reserve was established in Oregon in 1974 and currently encompasses 4,770 acres of protected estuarine habitats. The reserve management plan was last revised in 1994. South Slough habitats include degraded and relatively undisturbed examples of coastal forests, riparian habitats, freshwater wetlands (including beaver ponds), salt marshes, tidal flats and eelgrass beds. Restoration priorities include anadromous fish rearing habitat, salt marsh vegetation and invertebrate communities, and forest and upland habitat enhancement. Current restoration projects include salt marsh restoration (i.e. dike removal and restoration and creation of tidal creeks), replanting historically harvested upland forests and stream channel restoration and enhancement.

Tillamook Bay Comprehensive Conservation and Management Plan

This Comprehensive Conservation Management Plan (CCMP) addresses four priority problems in the Bay with coordinated goals, objectives and specific actions. Each action details the steps required to complete the action; identifies coordinating entities, other partners and completion dates; estimates costs; acknowledges regulatory issues; and plans for monitoring progress toward the CCMP goals and objectives.

Plan Elements

Goals

Analysis of plans reveals definite similarities among stated goals for habitat protection and restoration. These include: restoration and protection of habitat, including restoration and protection of physical, chemical, hydrological and biological processes; re-creation and protection of wetlands and tidal marshes, no net loss of wetlands, eelgrass beds or tidal marshes, and reversal of historic trends of degradation; maintenance of or increase in biodiversity, including restoration of anadromous and other fish populations, improvement of fish and wildlife health, control and prevention of further introductions of invasive or exotic species; improvement of water quality; increase in acreage of functioning tidal marshes; and conservation of existing habitat function.

Methods

Analysis of restoration plans revealed commonly used methods for restoring and managing habitat.

Restoration Methods:

- Remove or breach dikes and other structures such as jetties, sea walls and dams.
- Remove old tide gates or replace with fish-friendly tide gates.
- Remove fill or dredge material from former wetlands and tidal sloughs.
- Re-create or reconnect sloughs, streams and wetlands; re-establish natural hydrology by excavation or dynamite.
- Revegetate wetlands and upland buffers with native plants.
- Re-create correct ground elevation for natural revegetation of tidal wetlands to take place.
- Suspend maintenance of dikes (passive restoration).
- Control invasive or exotic species through mowing, herbicides, biological controls, uprooting, covering, taking inventory of existing populations and providing information to the public.

Strategies for Managing Habitat:

- Encourage restoration and protection efforts on private land.
- Identify and set priorities for habitat to be restored.
- Acquire land for restoration purposes.
- Establish and enforce shellfish closure criteria.
- Establish and enforce total daily maximum loads.
- Sample water quality regularly.
- Apply land use designations and zoning to direct development away from critical estuarine habitats (e.g., natural, conservation, development).
- Create or implement relevant state laws and county ordinances (e.g., land use, fisheries management).
- Mitigate habitat loss in unavoidable situations.
- Support basic scientific research to inform management decisions.
- Bring a sense of uniformity to restoration efforts.
- Implement a monitoring and adaptive management program after restoration.

Elements of Success

A review of restoration plans revealed some elements of planning and implementation that have proved successful.

Planning:

- Have clear and common goals, design and data.
- Work within a larger-scale restoration plan (based on landscape, watershed or coastal ecosystem) when available.
- Develop cooperation among agencies, stakeholders and interest groups such as watershed councils and "lead entities."
- Build on successful pilot or predecessor restoration programs.
- Work within existing shoreline land use designations.
- Establish a restoration advisory group that includes national science experts who will review plans.
- Use existing mitigation plans to identify candidate restoration sites.

Implementation:

- Monitor before and after alteration needed for restoration.
- Ensure sufficient funds (state, nonprofit sources, grants).
- Create and maintain a large database of relevant information.
- Control elevation when restoring vegetation to ensure that revegetation goals are met.
- Involve representatives from permit-issuing agencies and funding entities in the design process and project implementation through site visits.
- Develop public outreach, education and volunteer opportunities.

Information Needs

Some areas in current restoration efforts could be more successful with further research. The following is a list of factors that have contributed to less successful restoration practices.

- ❖ Lack of agency coordination and lack of a designated single responsible person.
- ❖ The newness of the implementation phase of the programs.
- ❖ Lack of resources for monitoring, public involvement or outreach.
- ❖ Lack of scientific data and tracking of changes in data.
- ❖ Imperfect results (e.g., low salt marsh returns instead of high salt marsh returns).
- ❖ Need for updating older restoration plans.
- ❖ Mapping problems.
- ❖ Use of plugs to direct water flow.
- ❖ Need for research in sedimentation process, fish stranding and ecosystem relationships.
- ❖ Need for a comprehensive look at historical estuarine data (e.g., where, what kind and how to restore).
- ❖ Rate of restoration too slow to meet resource and habitat management goals.
- ❖ Need for research on restoration in brackish water sloughs.
- ❖ Need for cost-effective methods to study the survival of biological populations in habitats or the changes in survival resulting from capacity or other limiting factors, such as available food sources.
- ❖ Need for research on the effects of climate change and rising sea level on estimated tidal levels, so that restoration plans can take these issues into account accurately.

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